Shallow Water Acoustics Studies

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LONG TERM GOALS

The long term goals of our shallow water acoustics work are to: 1) understand the nature of low frequency (10-1500 Hz) acoustic propagation, scattering and noise in shallow water when strong oceanic variability is present in the form of fronts, eddies, boundary layers, and internal waves (using the SW06 and QPE data, primarily) and 2) begin planning a 2015-16 bottom acoustics experiment in the Mid-Atlantic Bight and a 2018+ field experiment to look at the complicated boundary between deep and shallow water, i.e. the slope/canyon region. (Dates for experiments are approximate.)

OBJECTIVES

Our primary objectives this year were to: 1) finish manuscripts on the QPE shallow water acoustics/Uncertainty work, and submit them to IEEE JOE, 2) begin 2015 (bottom acoustics) and 2018 (shelfbreak, slope and canyon) experimental planning, both on an individual basis, and in conjunction with the whole ocean acoustics community, 3) continue work on modeling scattering by coastal internal waves and other features by developing simple "ocean feature model" based expressions for horizontal array coherence, temporal coherence, transmission loss, and scintillation index, 4) look at climate change effects in shallow water, and 5) further develop the theory of scattering of sound from a rough elastic solid seabed.

APPROACH

We devoted a fair effort this year towards finishing the manuscripts on the fall 2009 QPE Uncertainty experiment northeast of Taiwan. We have two manuscripts in press by IEEE JOE (one on canyons and one on the Dyer/Abbot PPD), and have two others in advanced preparation stage. The two in preparation are on: 1) the azimuthal dependence of TL, and how it compares at similar coastal sites worldwide, and 2) a demonstration that the predictive probability of detection (PPD) formalism of Dyer and Abbot works well, using QPE field data

The work on internal wave scattering of sound continues, and we have looked at mode coupling, ducting by curved waves, and high frequency energy fluctuations, among other topics. A JASA paper has been published on this work this year, and another is in advanced preparation.

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Planning for the next two shallow water experiments was also part of our effort this year, though at a modest level due to the delays in the experiments.

Finally, a good deal of progress has been made on using coastal ocean feature models to generate simple estimates of important acoustic quantities like array coherence length, transmission loss, and scintillation index, and results have been presented in an Acoustics Today paper.

WORK COMPLETED/ACCOMPLISHMENTS

As discussed above, we have had three peer reviewed papers and one popular magazine (Acoustics Today) paper published this year in our various research directions.

RESULTS

One of the more promising results this year was that we could actually predict horizontal array coherence in the presence of fronts and nonlinear internal waves from rather simple analytical feature model expressions. We have also generated simple form results for internal tides and eddies, and are preparing a JASA manuscript on those findings.

IMPACT/APPLICATIONS

The impact of our experiment should be: 1) an increased understanding of the propagation of sound through complicated coastal oceanography, 2) an eventual capability to model these effects for use in sonar performance prediction applications, and 3) showing that the PPD formalism for detection could be a useful extension of the usual sonar equation ROC curves.

TRANSITIONS

One eventual transition of our analyses will be to ONR's Uncertainty DRI program, where the interest is in "the error bars" in ocean acoustic field and system performance prediction. Another transition is the use of our SW06 internal wave data to verify a large "coastal oceanography plus internal wave" model being developed under a MURI that can eventually be used as a Navy standard model that works at all ocean scales down to the internal waves and finescale. Finally, the simple feature model expressions for coherence length, coherence time, TL and SI that we are generating could be very useful in showing how accurate one needs to be with larger scale models and theories in order to predict these quantities at an acceptable level.

RELATED PROJECTS

The SWARM acoustics/internal wave study, the PRIMER acoustics/shelfbreak front study, and ASIAEX experiment were direct predecessors of SW06, and examined some of the same acoustic scientific issues, only with far fewer measurement resources. The "Non-linear internal waves initiative" (NLIWI) was strongly related to our SW06 effort via the environmental support that the oceanographic moorings (and other PO measurements) provided. The QPE experiment, stressing acoustic and environmental uncertainty in a coastal environment, is also related. Finally, the MURI for full 3D modeling of coastal internal waves and acoustics will directly use our SW06 data for model verification.

PUBLICATIONS

[1] A.A. Shmelev, J.F. Lynch, Y.-T. Lin and H. Schmidt, "3D coupled mode analysis of internal-wave acoustic ducts," J. Acoust. Soc. Am. Vol. 135, pg. 2497 (2014). [published, refereed]

[2] C. Emerson, J.F. Lynch, P. Abbot, Y.-T. Lin, T.F. Duda, G.G. Gawarkiewicz and C.-F. Chen, "Acoustic Propagation Uncertainty and Probabilistic Prediction of Sonar System Performance in the Southern East China Sea Continental Shelf and Shelfbreak Environments," IEEE J. Ocean. Eng. (2014). [published, refereed]

[3] Y.-T. Lin, T.F. Duda, C. Emerson, G.G. Gawarkiewicz, A.E. Newhall, B. Calder, J.F. Lynch, P. Abbot, Y.-J. Yang and S. Jan, "Experimental and numerical studies of sound propagation over a submarine canyon northeast of Taiwan," accepted, IEEE J. Ocean. Eng. (2014). [published, refereed]

[4] J. Lynch, T. Duda, and J. Colosi, "Acoustical horizontal array coherence lengths and the 'Carey Number'", Acoustics Today **10** , 10 (2014).